

**WHAT IS CLAIMED IS:**

- 1           1.       A method of processing an input image, comprising:  
2           sub-sampling the input image to generate a thumbnail image; and  
3           detecting redeye pixel areas in the thumbnail image.
- 1           2.       The method of claim 1, wherein detecting redeye pixel areas  
2           comprises computing measures of pixel redness in the thumbnail image, and  
3           identifying a preliminary set of candidate redeye pixel areas based on the  
4           computed pixel redness measures.
- 1           3.       The method of claim 2, wherein pixel redness measures are  
2           computed based on a ratio of a measure of a red component of pixel energy to a  
3           measure of total pixel energy.
- 1           4.       The method of claim 2, wherein identifying the preliminary set of  
2           candidate redeye pixel areas comprises applying a two-dimensional redness filter  
3           to the computed pixel redness measures, wherein the redness filter is operable to  
4           compute a redness score based on a central kernel pixel area and a pixel area  
5           surrounding the kernel pixel area.
- 1           5.       The method of claim 4, further comprising applying a prescribed  
2           threshold to the computed redness scores to identify candidate redeye pixels.
- 1           6.       The method of claim 5, wherein detecting redeye pixel areas further  
2           comprises segmenting redeye pixels by scanning a redness map of the redness  
3           measures in stripes of one or more pixel lines and tracking objects containing  
4           candidate redeye pixels connected across stripes.
- 1           7.       The method of claim 4, wherein detecting redeye pixel areas further  
2           comprises filtering from the preliminary set each candidate redeye pixel area  
3           having a computed redness contrast relative to at least one respective neighboring  
4           pixel area less than a prescribed redness contrast threshold.
- 1           8.       The method of claim 7, wherein each candidate redeye pixel area  
2           having a computed redness contrast relative to each of a set of corresponding

3 surrounding pixel areas less than the prescribed redness contrast threshold is  
4 filtered from the preliminary set.

1 9. The method of claim 2, wherein identifying the preliminary set of  
2 candidate redeye pixel areas comprises enlarging a given candidate redeye pixel  
3 area having a dimension below a threshold size to generate an enlarged pixel  
4 area.

1 10. The method of claim 9, wherein identifying the preliminary set of  
2 candidate redeye pixel areas comprises comparing the enlarged pixel area to  
3 multiple pixel areas surrounding the enlarged pixel area, and selecting a pixel area  
4 to replace the given candidate redeye pixel area from among the enlarged pixel  
5 area and the surrounding pixel areas based on measures of redness computed for  
6 each of the enlarged pixel area and the surrounding pixel areas.

1 11. The method of claim 2, wherein detecting redeye pixel areas further  
2 comprises filtering from the preliminary set each candidate redeye pixel area  
3 located in an area of the digital image having a computed grayscale contrast  
4 relative to at least one respective neighboring pixel area less than a prescribed  
5 grayscale contrast threshold.

1 12. The method of claim 11, further comprising:  
2 computing measures of pixel grayscale in the digital image;  
3 computing, for a given candidate redeye pixel area, a candidate iris area  
4 centered at the given candidate redeye pixel area and having a size maximizing  
5 grayscale contrast between the candidate iris area and areas surrounding the  
6 candidate iris area;  
7 computing a measure of grayscale contrast between the candidate iris area  
8 and at least a portion of the areas surrounding the candidate iris area;  
9 and applying a threshold to the computed grayscale contrast measure to  
10 filter candidate redeye pixel areas from the preliminary set.

1 13. The method of claim 2, further comprising:  
2 identifying a pixel boundary of a pixel region surrounding a given  
3 candidate redeye pixel area;

4           classifying pixels within the pixel boundary as red pixels and non-red  
5           pixels by applying a threshold to the computed pixel redness measures; and  
6           filtering the given candidate redeye pixel area from the preliminary set  
7           when a set of contiguous red pixels extends from the given candidate redeye pixel  
8           area to the pixel boundary.

1           14.    The method of claim 13, further comprising identifying the set of  
2           contiguous pixels by scanning a redness map of the redness measures in stripes of  
3           one or more pixel lines and tracking objects containing red pixels connected  
4           across stripes.

1           15.    The method of claim 2, further comprising filtering candidate redeye  
2           pixel areas from the preliminary set based on proportions of detected skin tone  
3           pixels in regions respectively surrounding the candidate redeye pixels areas.

1           16.    The method of claim 2, further comprising pairing candidate redeye  
2           pixel areas in the preliminary set, and filtering unpaired candidate redeye pixels  
3           areas from the preliminary set.

1           17.    The method of claim 16, wherein pairing candidate redeye pixel  
2           areas comprises comparing a candidate texture pattern computed for a candidate  
3           pair of candidate redeye pixel areas in the preliminary set with a reference texture  
4           pattern.

1           18.    The method of claim 17, wherein comparing the candidate texture  
2           pattern with the reference texture pattern comprises generating a feature vector  
3           representative of the candidate texture pattern and comparing the generated  
4           feature vector with a statistical model of the reference texture pattern.

1           19.    The method of claim 18, wherein generating the feature vector  
2           representative of the candidate texture pattern comprises mapping a candidate  
3           redeye pair region encompassing the candidate redeye pair to a standardized  
4           candidate redeye pair template.

1           20.     The method of claim 19, wherein mapping the candidate redeye pair  
2 region comprises cropping a pixel region from a grayscale map of the thumbnail  
3 image, rotating the cropped pixel region, and scaling the rotated pixel region.

1           21.     The method of claim 20, wherein mapping the candidate redeye pair  
2 region comprises normalizing and equalizing the scaled pixel region.

1           22.     The method of claim 19, wherein generating the feature vector  
2 representative of the candidate texture pattern comprises converting the mapped  
3 candidate redeye pair region to the feature vector.

1           23.     The method of claim 1, further comprising detecting redeye pixel  
2 areas in the input image, and generating a set of detected redeye pixel areas by  
3 merging redeye pixel areas detected in the input image with redeye pixel areas  
4 detected in the thumbnail image.

1           24.     The method of claim 1, further comprising correcting redeye in the  
2 input image based on redeye pixel areas detected in the thumbnail image.

3           25.     The method of claim 24, wherein correcting redeye comprises  
4 mapping the detected redeye pixel areas to the input image.

1           26.     The method of claim 25, wherein correcting redeye comprises  
2 enlarging redeye pixel areas mapped to the input image.

1           27.     The method of claim 26, wherein the mapped redeye pixel areas are  
2 enlarged by amounts decreasing inversely with respect to original sizes of the  
3 mapped redeye pixel areas.

1           28.     The method of claim 26, further comprising cropping corners from  
2 each of the enlarged redeye pixel areas.

1           29.     The method of claim 25, further comprising classifying pixels as  
2 redeye pixels for correction before mapping detected redeye pixel areas to the  
3 input image.

1           30.     The method of claim 24, wherein correcting redeye comprises  
2 identifying discrete redeye pixel areas separated from eyelid regions.

1           31.     The method of claim 30, wherein identifying discrete redeye pixel  
2 areas comprises comparing at least one redeye pixel area size dimension to a  
3 threshold.

1           32.     The method of claim 31, wherein a discrete redeye pixel area is  
2 identified based at least in part on a prescribed fraction of a respective grayscale  
3 iris area centered at a corresponding pixel area and having a size maximizing  
4 grayscale contrast between the grayscale iris area and areas surrounding the  
5 grayscale iris area.

1           33.     The method of claim 30, wherein correcting redeye comprises  
2 classifying pixels in each non-discrete redeye pixel area based on skin tone  
3 coloration.

1           34.     The method of claim 24, wherein correcting redeye comprises  
2 classifying pixels in each redeye pixel area based on a redness threshold.

1           35.     The method of claim 24, wherein pixels are classified on a pixel-by-  
2 pixel basis.

1           36.     The method of claim 24, wherein each pixel is classified with  
2 reference to an adjacent, previously-classified pixel.

1           37.     The method of claim 24, wherein correcting redeye comprises  
2 classifying pixels between concentric inner and outer bounding regions based on  
3 a grayscale threshold.

1           38.     The method of claim 37, further comprising correcting original color  
2 values of pixels in a redeye pixel correction region encompassing pixels classified  
3 as redeye pixels.

1           39.     The method of claim 38, wherein original color values of pixels in  
2 the redeye pixel correction region are corrected by desaturating original color  
3 values.

1           40.     The method of claim 39, wherein original color values are  
2 desaturated by respective amounts varying with pixel location in the final pixel  
3 mask.

1           41.     The method of claim 39, wherein original color values of pixels in  
2 the redeye pixel correction region are corrected by darkening the original color  
3 values.

1           42.     The method of claim 38, further comprising correcting original color  
2 values of pixels in a smoothing region surrounding the redeye pixel correction  
3 region.

1           43.     The method of claim 42, wherein original color values of pixels in  
2 the smoothing region are corrected by an amount decreasing with distance from  
3 the given redeye pixel correction region.

1           44.     The method of claim 43, wherein original color values of pixels in  
2 the redeye pixel correction region are corrected without reference to position  
3 within the redeye pixel correction region.

1           45.     The method of claim 37, further comprising computing a size of the  
2 inner bounding region between a given redeye pixel area size and a  
3 corresponding grayscale iris area size, and computing a size of the outer bounding  
4 region larger than the computed size of the inner bounding region by a  
5 predetermined relative amount.

1           46.     The method of claim 24, wherein original color values of pixels are  
2 corrected based on integer arithmetic computations.

1           47.     The method of claim 1, further comprising correcting redeye in the  
2 thumbnail image based on redeye pixel areas detected in the thumbnail image.

1           48.     The method of claim 47, further comprising displaying the  
2     thumbnail image with corrected redeye, and correcting redeye in the input image  
3     based on redeye pixel areas detected in the thumbnail image in respond to a user  
4     command.

1           49.     A method of processing an input image having lines of pixels with  
2     original color values, comprising:  
3             detecting one or more redeye pixel areas corresponding to respective areas  
4     in the input image;  
5             classifying each pixel in the input image corresponding to the detected  
6     redeye pixel areas as a redeye pixel or a non-redeye pixel on a line-by-line basis  
7     without reference to pixels in adjacent lines; and  
8             correcting the original color values of pixels in the input image classified as  
9     redeye pixels.

1           50.     The method of claim 49, wherein a pixel in a given line is classified  
2     with reference to an adjacent, previously-classified pixel in the given line.

1           51.     The method of claim 49, wherein correcting redeye comprises  
2     identifying discrete redeye pixel areas separated from eyelid regions.

1           52.     The method of claim 51, wherein identifying discrete redeye pixel  
2     areas comprises comparing at least one redeye pixel area size dimension to a  
3     threshold.

1           53.     The method of claim 52, wherein a discrete redeye pixel area is  
2     identified based at least in part on a prescribed fraction of a respective grayscale  
3     iris area centered at a corresponding pixel area and having a size maximizing  
4     grayscale contrast between the grayscale iris area and areas surrounding the  
5     grayscale iris area.

1           54.     The method of claim 51, wherein correcting redeye comprises  
2     classifying pixels in each non-discrete redeye pixel area based on skin tone  
3     coloration.

1           55.     The method of claim 49, wherein correcting redeye comprises  
2     classifying pixels in each redeye pixel area based on a redness threshold.

1           56.     The method of claim 49, further comprising correcting original color  
2     values of pixels classified as redeye pixels by desaturating original color values.

1           57.     The method of claim 49, further comprising correcting original color  
2     values of pixels classified as redeye pixels by darkening the original color values.

1           58.     A system for processing an input image, comprising a redeye  
2     detection module operable to:  
3                 sub-sample the input image to generate a thumbnail image; and  
4                 detect redeye pixel areas in the thumbnail image.

1           59.     The system of claim 58, wherein the redeye detection module  
2     computes measures of pixel redness in the thumbnail image and identifies a  
3     preliminary set of candidate redeye pixel areas based on the computed pixel  
4     redness measures.

1           60.     The system of claim 59, wherein the redeye detection module  
2     applies a two-dimensional redness filter to the computed pixel redness measures,  
3     wherein the redness filter is operable to compute a redness score based on a  
4     central kernel pixel area and a pixel area surrounding the kernel pixel area.

1           61.     The system of claim 59, wherein the redeye detection module  
2     enlarges a given candidate redeye pixel area having a dimension below a  
3     threshold size to generate an enlarged pixel area.

1           62.     The system of claim 59, wherein the redeye detection module filters  
2     from the preliminary set each candidate redeye pixel area located in an area of the  
3     digital image having a computed grayscale contrast relative to at least one  
4     respective neighboring pixel area less than a prescribed grayscale contrast  
5     threshold.

1           63.     The system of claim 59, wherein the redeye detection module is  
2     further operable to:



3           identify a pixel boundary of a pixel region surrounding a given candidate  
4       redeye pixel area;

5           classify pixels within the pixel boundary as red pixels and non-red pixels  
6       by applying a threshold to the computed pixel redness measures; and

7           filter the given candidate redeye pixel area from the preliminary set when a  
8       set of contiguous red pixels extends from the given candidate redeye pixel area to  
9       the pixel boundary.

1           64.     The system of claim 59, wherein the redeye detection module filters  
2       candidate redeye pixel areas from the preliminary set based on proportions of  
3       detected skin tone pixels in regions respectively surrounding the candidate redeye  
4       pixels areas.

1           65.     The system of claim 59, wherein the redeye detection module pairs  
2       candidate redeye pixel areas in the preliminary set and filters unpaired candidate  
3       red eye pixels areas from the preliminary set.

1           66.     The system of claim 58, wherein the redeye detection module  
2       detects redeye pixel areas in the input image and generates a set of detected  
3       red eye pixel areas by merging redeye pixel areas detected in the input image with  
4       red eye pixel areas detected in the thumbnail image.

1           67.     The system of claim 58, further comprising a redeye correction  
2       module operable to correct redeye in the input image based on redeye pixel areas  
3       detected in the thumbnail image.

1           68.     A system for processing an input image having lines of pixels with  
2       original color values, comprising:

3           a redeye detection module operable to detect one or more redeye pixel  
4       areas corresponding to respective areas in the input image; and

5           a redeye correction module operable to classify each pixel in the input  
6       image corresponding to the detected redeye pixel areas as a redeye pixel or a non-  
7       red eye pixel on a line-by-line basis without reference to pixels in adjacent lines,  
8       and to correct the original color values of pixels in the input image classified as  
9       red eye pixels.